

Final Report

Behavioral Strategies and Problems in Scanning
and Interpreting Tactual Displays

Edward P. Berla¹

American Printing House for the Blind, Inc.

Louisville, Kentucky

27 January, 1972

Behavioral Strategies and Problems in Scanning and Interpreting Tactual Displays

Edward P. Berla¹

The purpose of this study was to determine the behavioral strategies and techniques that experienced adult blind users employed in exploring tactual maps and the strategies they employed in performing some simple map reading tasks. This study was not undertaken to provide absolute answers to the myriad of problems that exist in the area of tactual maps, but rather it was a heuristic device for generating information, ideas, hypotheses, and some definitive behavioral problems that confront the blind tactual map reader.

Background

There are at least three general problems in the production and use of maps. The first is map legibility. The practice of direct transcription of a print map into a tactual counterpart often results in illegible, unreadable, and infrequently used maps. Research has been conducted on the factors related to the legibility of symbols (Nolan & Morris, 1971) and in the total design of maps (Nolan & Morris, 1971; Wiedel & Groves, 1969), but these investigations have only begun to tackle the myriad of problems inherent in the legibility of complex tactual displays. The second problem concerns the manner in which information is displayed on a tactual map so that the reader, through some behavioral means, can obtain information to aid his understanding of the environment. A third problem is the behavior of the blind map reader, his strategies and techniques for reading tactual displays. This problem has been almost entirely ignored in the literature. The specific focus of this investigation was the behavioral strategies and techniques that blind ss used to read tactual maps. Previous research (Nolan & Morris, 1971) showed

that blind Ss in both primary and secondary school have so little experience in reading tactual displays that more than two-thirds of them were unable to locate highly discriminable symbols on a map. Observations suggest that the principal factor underlying their lack of ability to locate the symbols was that more than two-thirds of the Ss did not search the entire map. There was apparently no systematic scanning strategy and the Ss tended to perserverate on one small portion of the map and/or scanned it in a haphazard and seemingly random fashion.

One could attempt to remedy the situation by logically determining a number of strategies which could be employed in searching a tactual display. However, it seemed more valid to determine what strategies and techniques experienced adult blind users employ in reading tactual displays and then these strategies, techniques, and behaviors could be investigated with blind children. Although it is not valid to generalize the behaviors of adult users to young children, it does provide a source of information on which to base subsequent empirical investigations.

In this study 12 adult blind Ss were sent a tactual pseudomap and asked to perform a number of map reading tasks. Subsequently, each S was interviewed over the telephone and asked to describe the strategies, techniques, and problems encountered in performing the tasks and in reading tactual materials in general.

Method

Subjects

The 12 blind adults who participated in this study were known to be skilled users of complex tactual materials. The Ss participating in this study were: Miss Christine Baugh, Dr. Thomas Benham, Dr. John Crandell, Dr. Mae Davidow

Mr. Anthony Evancic, Dr. Emerson Foulke, Mrs. Betty Gissoni, Mr. Fred Gissoni, Mr. Ross Huckins, Dr. Arthur Lown, Dr. Abraham Nemeth, and Mr. Vito Proscia.

Materials

The map contained three kinds of symbols; areal, linear, and point. The tactual map used in the study is presented in Figure 1. The maps were produced through vacuum forming styrene plastic from male molds which were made from a photoengraving process. The outer dimensions of the map were 15 x 15 inches. The height of each kind of symbol was: areal, .015 inch; linear, .025 inch; and point, .035 inch. The separation between symbols was .150 inch.

 Insert Figure 1 about here

Procedure

Each S was contacted and asked to participate in the study. If he agreed to participate, the map presented in Figure 1 was sent along with a copy of the following instructions:

Instructions

The enclosed pseudomap consists of a number of areal, point, and linear symbols. Lay the map and the key on a table top in their proper orientation by placing the side which has 2 dots in each corner at the top. Place the key which consists of 3 different symbols (1 point, 1 areal, and 1 linear symbol) next to the map.

Task #1 - Location of Point Symbols - On the map there are 5 instances of the 1 point symbol given in the key. We would like you to scan the map and locate each of the 5 instances of this one symbol. As you scan the map please pay particular attention to the techniques you use, such as the hand and finger motions you use, the number of fingers you use, what parts of the fingers you use, and what difficulties you have in locating the symbols.

Task #2 - Location of Areal Symbols - On the map there are 6 instances of the 1 textured areal symbol given in the key. We would like you to scan the map and locate each of the 6 instances of this one symbol. Again pay particular attention to the techniques you use.

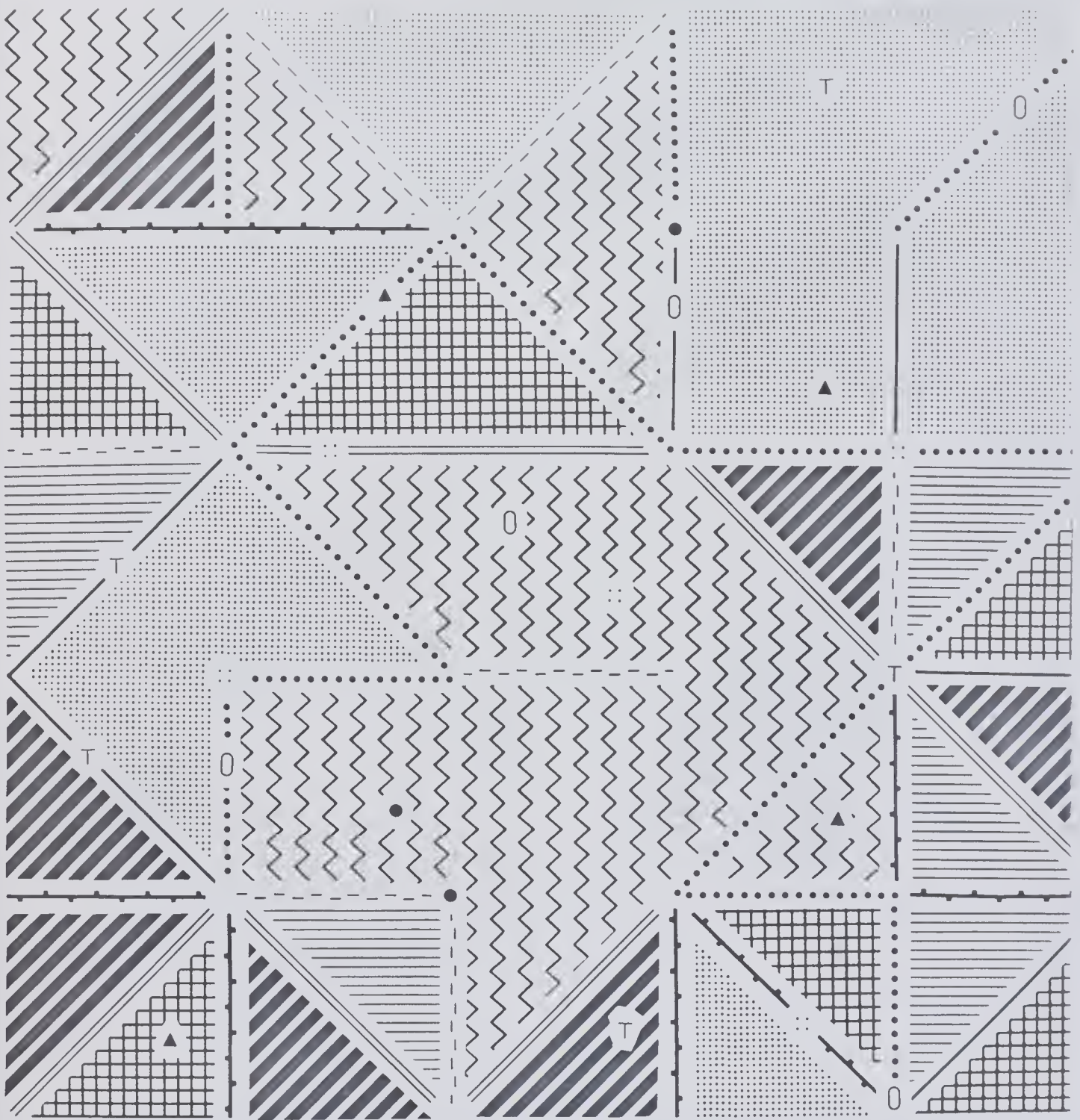


Fig. 1. Example of pseudomap employed in study. (Not shown: on the pseudo sent to the subjects, dotted tabs were fastened on the top edge so that the map could be properly oriented.)

When you have completed these tasks try and determine the similarities and differences in the techniques you used in scanning the map for the 2 different kinds of symbols. For example, were your finger motions the same or were there subtle differences?

Task #3 - Following a Track - The remaining symbol in the key is a dotted track. At the beginning of the dotted track there is a point symbol which indicates the starting point. On your map you will find the starting point 3 inches from the extreme lower right hand corner. Once you have located the starting point, we would like you to follow the track represented by the dotted linear symbol until you come to the goal which is signified by the same point symbol as you began with. Again, we would like you to pay particular attention to the strategies and techniques you use in following the track and experiment with alternative strategies.

When you have completed these tasks we would like you to think about and possibly make a list of the techniques and tasks you think are necessary for efficient map reading.

During the recorded telephone interview we would like you to have the map, the key, and any notes you have made in front of you for easy reference. Please remember the date and time for our scheduled recorded interview.

Subsequently, each S was interviewed over the telephone. All the interviews were tape recorded and each S was informed that the conversation was being recorded and their permission to record was obtained.

Results and Discussion

Rather than describing each S's strategies, techniques, and comments, an attempt was made to delineate the major commonalities and dimensions of difference.

Scanning Patterns

One vs. Two Hands

One obvious difference was the fact that some Ss scanned the map using only one hand while other Ss used two hands. With two hands about twice as much area can be covered as compared to using only one hand and thus increases the tactual field of view. It was suggested that scanning the map with two hands at the same time also results in a better notion of the two-dimensionality of the map, its spatial organization, and extent.

Other Ss searched the map with one hand while the second hand served as a reference point along the side of the map. The reference hand determined how far down the map to scan and reduced the possibility of scanning over the same area twice or skipping a section of the map. For example, some Ss scanned the map as if they were reading a braille book. The left hand was placed on the left edge of the map and the right hand scanned from left to right across the map as if reading a line of braille. When the right hand reached the right hand edge of the map the scanning hand would return to the reference hand and the reference hand would move down the map about the width of a braille line. The reference hand moved down the map each time indicating the next horizontal section of the map to be scanned. Thus, by using a reference hand it permitted the S to define the width of the scanning band and allowed the S to maintain his orientation and location on the map. The Ss using a two hand strategy indicated that location and orientation on the map was not a problem and that they could maintain their orientation and location quite easily while scanning with two hands. Evidently these Ss used some arbitrary reference points on the map to maintain their orientation.

Horizontal Scan

Several Ss using either one or two hands scanned across the map from left to right or right to left. The Ss differed with respect to what they did after they completed scanning a horizontal section of the map. Some Ss picked their hand(s) up and returned it to the side of the map they began on and subsequently scanned across in the same direction. Other Ss, when they completed scanning a horizontal section of the map, moved their hand(s) down and scanned back across the map in the opposite direction from which they came. A possible disadvantage of picking up the hand(s) and returning to one side may be that it takes more time and increases the probability of

losing one's location on the map as compared to moving the hand(s) down and scanning back in the opposite direction.

Vertical Scan

Several Ss using either one or two hands would scan the map in columns, top to bottom or bottom to top. As with the horizontal scan the Ss differed with respect to what they did after they had completed scanning a vertical section of the map. Some Ss, after scanning from the top to the bottom of the map, would pick up their hand(s) and return to the top of the map so that the next vertical section of the map could be scanned. Other Ss, after scanning from the top to the bottom, would move their hand(s) over horizontally and scan back up the map from bottom to top. As with the horizontal scan, lifting the hands and returning to one side may increase time and/or result in disorientation.

Scanning horizontally or vertically may make a difference in the speed and/or accuracy of the search task. For a horizontal scan the width of the area covered (scanning band) is limited by the physical extent of the fingertips employed. Assuming that three fingers can be used, the fingertips cover a band width of approximately one-half to one inch, then a map which is 15 inches long would require 15-30 horizontal scans to cover the entire map. For a vertical scan, the scanning band is determined by combined width of the number of fingers used. Assuming that the first three fingers of one hand can be employed to scan the map and the average width of three fingers is between one and two inches, then it would require from eight to fifteen scans to adequately cover the entire map. If two hands are used in a horizontal scan, with one hand trailing behind the other, there is no increase in the amount of area covered because only the fingertip length defines the width of the scanning band. However, if two hands are used in a vertical scan this

doubles the field of view because it doubles the number of fingers scanning down the page. Thus, a two hand vertical scan should result in a dramatic reduction of time because fewer successive scans would be necessary to cover the entire map. However, a horizontal scan permits greater redundancy, since each of the fingers must cover approximately the identical area that each of the other fingers cover. By using two hands this could double the redundancy because one hand would follow the other resulting in twice as many fingers covering the identical area. Thus, it would be interesting to determine whether a vertical or horizontal scan is faster and/or more reliable than the other.

Assymetrical Horizontal Scan

This strategy is a variation of the horizontal scan. In this strategy both hands were placed on the top central part of the map. The left hand scanned to the left edge while the right hand scanned to the right edge of the map. When both hands reached the opposite sides of the map, they both scanned back toward the center of the map covering the same area as they scanned before. When the hands met in the center of the map they were moved down and the whole process was repeated.

Perimeter or Clockface Scan

In this strategy the hand(s) scanned around the perimeter of the map and successively moved closer to the center, each time scanning smaller, inner perimeters. There were two different hand motions that were utilized. In one case, both hands moved in the same direction around the map with one hand following the other. In the second case, one hand moved in a clockwise direction around the perimeter of the map while the other hand moved around the perimeter in a counterclockwise motion.

Bounded Search

In this strategy square or rectangular areas were outlined on the map and then searches were made within the bounded areas for particular symbols. If the map does not lend itself well to defining these areas then "imaginary" squares could be arbitrarily defined and each "imaginary" square could be systematically searched. This strategy may have an organizational advantage in that one could remember or tag the various cells or bounded areas and remember the symbols and organizational features of the map by remembering the spatial location of the cells and the details within them.

Density Distribution Scan

In this strategy the map was scanned swiftly to determine where the greatest number of symbols were. A detailed examination then began with the area of the map which had the fewest symbols and then continued from the area of least concentration to the area of greatest concentration. Thus, this kind of search enabled the S to order the task along a dimension of difficulty. However, it required the S to remember what areas had already been searched and, if there were several instances of the same symbol on the map, there was the possibility that the S could identify the same symbol twice or miss a symbol.

Spoked Wheel Scan

In this strategy the center of the map and/or a distinctive symbol near the center of the map was located. Then the center of the map and/or the distinctive symbol on the map served as a reference point around which to organize the other symbols on the map in a spatial array. To search for other symbols on the map one hand held the reference point while the other hand scanned from the center to the outer edge in successive scans like the spokes of a wheel. This strategy provided for a specific organizational structure and potentially had the advantage of allowing the reader to obtain

information about the spatial array in a systematic and integrated fashion.

From a theoretical standpoint all of the strategies described have advantages and disadvantages. One simple way to proceed is to train children at different grade levels in the mechanics of each of these strategies to determine which are most efficient and accurate for locating symbols on a map. In addition, it is important to determine what specific information each strategy allows one to obtain that the others do not. It may be that some of these strategies are more effective for organizing and determining spatial relationships than others. Some may be more appropriate for different age ranges and levels of functioning.

Hand and Finger Utilization

Most Ss indicated that the primary fingers used in obtaining information were an index and middle finger. Several Ss indicated that the ring finger was of use in obtaining information, but almost all the Ss indicated that the thumb and little finger provided very little information and were mainly used for support. The Ss also indicated some possible differences in the parts of the fingers used in searching a map for areal as opposed to point symbols. For areal symbols the hand(s) were placed flat on the map and more of each finger was used to pick up information. For point symbols most Ss only used the fingertips. However, some Ss used only the fingertips in searching for both kinds of symbols. Thus, it may be important to determine how many fingers and what part of the fingers can be utilized in locating various types of symbols.

Another important dimension has to do with the micromotions of the fingers as one searches the map. As is well known in teaching braille reading, additional motions such as up and down or circular motions are discouraged

This is principally because each braille cell fits under a fingertip and the braille information is displayed in a linear fashion. On a map, however, not all of the symbols are small enough to fit under a fingertip and the information is not displayed in a linear fashion. Some of the Ss used additional micromotions when they were searching the map. Some used an up and down motion, a wavy motion, or a circular motion as their hand(s) scanned the map even though they indicated that they do not use these motions when they read braille. The question is whether these micromotions of the fingers facilitate the detection and discriminatory capacity or whether they hinder it? It is well known that movement is a necessary condition for adequate tactual perception. It may be that these additional micromotions aid in the tactual perceptual process for tactual displays incorporating symbols that are not of a punctiform configuration, that are larger than the traditional braille cell, and that are not displayed linearly.

Another difference between Ss who used a two hand strategy was that some Ss maintained a constant distance between the hands as they scanned the map, while other Ss varied the distance between their hands. In addition, some Ss indicated that when using two hands, each hand worked independently picking up different information, while other Ss indicated that one hand picked up information while the other hand served a checking function. Some Ss suggested that the hands engaged in both types of activities.

Areal vs. Point Symbols

Most Ss indicated that the areal symbols were easier to locate than the point symbols because the areal symbols were larger than the point symbols. Furthermore, when searching for an areal symbol some Ss indicated that they attempted to detect a change in the "rhythm" since textured surfaces provide a sort of rhythmic pattern.

In searching for point symbols it was suggested that the whole hand could be used in an attempt to detect "bumps" on the map. When a "bump" is detected the index finger can then be brought to bear on the symbol to determine if it is the target symbol.

Tracking

The third task that the Ss were asked to perform was to follow a dotted track from the starting point indicated by the 0 in the lower right hand corner of the map shown in Figure 1 and follow it to the goal which was indicated by another 0 at the lower left. There was notable consistency between individuals in the way they followed the track. With the exception of one person, all used two hands in which one or two fingers of one hand would lead, while one or two fingers of the second hand would trail behind. When a choice point was reached (a right or left turn), one hand would hold the track while the other hand would scan ahead looking for the continuation of the track.

One S used a one hand strategy which was remarkably similar to the two hand strategy just described. With a one hand strategy one or two fingers followed the track and when a choice point was reached, one finger held the track while the other finger searched around for the continuation of the track. It was suggested that when using only one hand, the thumb could be placed on the track as a pivot and then one or more of the fingers could be used to search for the continuation of the track. In this way the thumb-to-index-finger span could be used to locate the continuation of the track.

Orientation

An obviously important starting point for all map reading tasks is to place the map in its proper orientation. To accomplish this, there needs to be some easily accessible stimulus with which to differentiate the top from

the bottom of the map. In the present situation tabs were provided at the top two corners of the map. All the Ss indicated that they aligned the bottom of the map with the table top or with the horizontal plane of their body. Subsequently, all the Ss indicated that they gave the map a swift scan before proceeding with the required tasks. The swift scan was a preliminary activity which consisted of running both hands over the entire map and usually required less than one minute. The Ss suggested that a swift scan provided useful information for subsequent tasks. With a swift scan the Ss indicated that they were able to determine the overall size of the map, an approximate notion of the number of symbols on the map, the nature of some of the symbols, the density, distribution, and general location of some of the symbols. It also enabled the Ss to determine the highly distinctive features of the map which subsequently served as reference points around which to organize a search process and may have formed the basis of a tactual-kinesthetic image of the map. Apparently the swift scan provided an abundance of information in an extremely short span of time. From an empirical standpoint, research could focus on just how much information can be gained from a swift scan, how much is remembered, the organization of that information, and how this information is employed in subsequent map reading tasks.

Just as one needs to know his spatial orientation in the environment, one also needs to know one's spatial orientation on a tactual display such as a map. Most Ss emphasized the need for gross differentiations on the map such as top, bottom, left, right, north, south, east, and west and the use of the sides, corners, and distinctive features of a particular map as reference points with which to orient oneself on the map. It was suggested that the more reference points one has, the better is one's sense of spatial orientation and spatial relationships on the map. Some Ss suggested that the

north part of the map be oriented in the same direction as physical north because to call the top part of the map north and then have the top of the map oriented, for example, toward the west wall of the room would be confusing to blind children if they were learning about compass directions. One S suggested that to determine spatial direction on a map one should liken the map to a clock face with the numbers evenly spaced around the outer edge of the map. The S could then use the clock face analogy to specify the location of symbols. The location of a symbol on the map could be specified by giving a number and its distance from the center of the map.

Measuring and Estimating Size and Distance

An important task in reading maps is often knowing the physical distance between two points on the map. This can be accomplished in a number of ways. One set of techniques suggested was to use an external measuring device. An obvious way to proceed would be to locate the two points and then use a tactile ruler to measure the distance between them. If the distance was greater than 12 inches one could lap off successive segments with a ruler. It was suggested that for very large distances one could use a tactile yardstick or else measure the distance with an ordinary yardstick and then slide a tactile ruler along the printed yardstick. Another technique suggested was to take a piece of string or wire and extend it between the two points on the map and then measure the string or wire on a tactile ruler or yardstick. If a tactile ruler were unavailable, any object whose physical length was known could be used in order to get an approximate estimate of the physical distance. One S suggested that index cards could be used quite effectively. For example, with a 3 x 5 inch index card a distance of three or five inches could be measured exactly. For distances less than five inches, the

card could be folded in half along one axis to obtain a length of one and one-half inches and by folding it along the other axis a length of two and one-half inches could be obtained. Thus, by combining the flat and folded techniques with index cards, distance can be measured quite precisely when a ruler is not available.

A second set of techniques was to utilize the known sizes of parts of the hand. One could measure the various lengths and diameters of the fingers and hand and use these to estimate distance when no other means were available. Some suggested techniques were fingerspan (the length from the tip of the thumb to the tip of the middle or index finger), hand width (the width of four fingers of one hand lying on a flat surface), finger width (the width of any finger), finger length (the length of any finger). Thus, the S, by knowing the physical length of the various hand and finger parts, could obtain a fairly accurate estimate of the physical distance between two points on a map. There is at least one problem inherent with using a part of the body for measuring physical distance. Young children, of course, keep growing and the physical sizes of the extremities keep changing.

A third technique was more complicated and relies on an accumulated core of experience in measuring distance. This technique involved a tactual-kinesthetic, time-distance relationship. Simply stated, the S traversed the distance between the two points with one or two fingers. Then on the basis of previous experience from measuring other known physical distances in the same manner, an estimate of the physical distance just traversed was obtained. To use this technique, the S needs a wealth of experience in measuring known physical distances with this method, so that a tactual-kinesthetic memory is acquired from which to compare an unknown length. In addition, the concept of time-distance invariance needs to be developed (i.e., an object moving at

a fixed rate covers a fixed distance). Thus, a map reader could develop all three techniques to provide flexibility and efficient and accurate estimates of physical distance.

Comparing the Sizes and Shapes of Two Bounded Areas

A more complicated task is the estimation of the area of one or more shapes. This involves not only measuring physical distance, but also obtaining some notion of the bounded area's shape so that an appropriate mental calculation can be performed. For example, if the shape is a square all one needs to do is to square the length of one side, if it is a rectangle then multiply $L \times W$. When the shapes become more complex mental calculations are less precise because formulas for them are not well known.

In the simplest case the task may be to determine whether one area is larger or smaller than another area. In this case there were a number of techniques which were suggested. If the map is dissectable, one bounded area could be taken out and laid on top of the other bounded area to determine which one was larger, or two pieces of paper could be cut to the size of the areas and placed over one another. A third technique was to place the palm of the hand over each bounded area to determine which bounded area covered more of the palm. A fourth technique was to measure the average width and height of an area and then calculate its area. A fifth technique was to imagine the smallest square which would fit into the bounded area and then to imagine the smallest square that would encompass the bounded area. Then, the area of the bounded-area would be somewhere between the sizes of the two imaginary squares.

Another set of questions is the type of finger and hand techniques to use when estimating the size or shape of two areas. Is it better for young children to use the same hand or should the two shapes be compared

simultaneously, one with each hand, or a combination of both of these? Should one trace the perimeter or lay one's hand flat on the shape? How should the contour be traced? Should one finger of one hand be used to circumscribe the shape or should two hands be used? What direction should the hands proceed? Should the fingers of both hands proceed in the same direction around the shape or in opposite directions around the shape? Are these techniques valid for blind ss of all ages or is there a developmental change with some techniques being more accurate and efficient at different ages?

Keys

A number of questions arise in relation to keys. How many symbols can be put on a key before the key becomes burdensome and difficult to use? Are there age/grade developmental differences in the number of symbols a child can handle adequately? When should keys be introduced in the map reading task? Should a child begin by memorizing a key rather than referring to it often? The ss varied greatly in suggestions related to keys. Some ss suggested using keys early in map training, other ss suggested using them only after other skills had been developed. Some ss thought that memorization was better than referring often to the key. Some ss suggested that the number of symbols be kept to a minimum (4-5) and gradually increased in number. Many ss suggested that children be taught to refer to the key with one hand while holding his location with the other. In memorizing keys a few ss suggested that it might be easier to memorize some symbols than others. It was suggested that it might be easier to memorize symbols which are of different shapes as compared to symbols which are of different textures. Thus, the use of keys opens up the whole area of tactual memory and the factors which facilitate and interfere with encoding, storage, and

retrieval of tactual information.

Clutter

One often used word when referring to maps that are difficult to read is clutter. What factors produce clutter? As it turns out, different people mean different things when they refer to clutter. The factors suggested were: irrelevant information (dots, lines, textures), too many symbols, spacing between symbols, too many different symbols, too many similar symbols, the similarity of symbols irrespective of how many there are, and too many symbols per unit of area. All of these factors play a role in tactual perception, but just how was not apparent for all the factors mentioned. But most important, no information is available on how these factors interact with each other or how these variables affect each other in reading a tactual display. The word clutter appears to be a "wastebasket" term for everything that is currently wrong with tactual maps and more research is needed to determine what factors contribute to legibility and perceptual clarity.

Teaching Map Reading

All of the Ss interviewed suggested that map reading begin at the third grade or lower. Many Ss suggested that maps be introduced as early as kindergarten. Initially, children should be taught basic texture and shape discrimination skills and concepts. Although the following list is far from exhaustive, it presents some basic concepts and activities that were deemed necessary by the Ss in this study:

1. Meaning of a symbol. The child needs to develop the concept of symbolization. One teacher suggested that the classroom teacher could begin by placing four objects on a desk such as a spoon, comb, pencil, and book. These objects would be placed on the top, bottom,

left, and right sides of the desk. After the children were able to locate the objects on the desk using directional instructions (left, right, top, bottom) or compass directions (N, S, E, W) the teacher could replace the objects with the words for the objects, showing that the word can stand for the object. Next, the teacher could replace the words with the first letter of each word, thus showing that a letter symbol can stand for an object.

2. Lines, point, and areal symbols. There was disagreement as to which of these three kinds of symbols are easier to discriminate. However, some suggestions for teaching these symbols were as follows: Different maps could be designed using only one kind of symbol and the child would be asked to perform a number of tasks, like locating a particular symbol or specifying its location or relation to some other symbol. Maps could also be developed to present a variety of symbols and the child could perform the same task on this map. The maps could then be gradually increased in complexity (i.e., by increasing the number of the symbols on the map).
3. Discriminating bounded space. Children should be taught that bounded areas can be differentiated by the type of line that bounds them, by the shape of the bounded area, and/or the texture of the area within the bounded space.
4. Representations of the environment. Probably one of the most emphasized points was that, in beginning map reading instruction, maps should represent concrete situations that are highly familiar to the child such as a map of his classroom, bedroom, neighborhood campus, the route he takes when going from one classroom to another classroom, or from building to building, etc. Thus, for young blind children, maps

would take on meaning and they could be taught that maps can represent environments that they have never had contact with.

5. Spatial relationships and memory. The child should be taught that when reading a map he can gain certain information that he can retain for further use. For example, one reader suggested that in a map of the classroom, the teacher could "hide" candy in various parts of the room and then indicate to the child on a map where the candy was and tell him to find it. Or, the teacher could ask each child to traverse a path on the map to indicate how he would get to someone else's desk or a certain part of the room if he were at some given location, or the alternate paths one could take to get from his desk to someone else's desk.

Finally, all the readers were asked if they thought tactual representations added anything above and beyond a verbal description. All agreed that tactual maps were necessary and important for the education of blind children and that when a verbal description is combined with a tactual representation it provides for the most meaningful educational experience.

Conclusions

These interviews have provided basic information on a variety of behavioral techniques and problems related to tactual displays of information. Of course, the information obtained here was limited to experienced, adult blind readers on a limited number of behavioral tasks. Further empirical study needs to be undertaken so that generalizations can be made to children under a variety of behavioral tasks. It is apparent that the problem of research on the legibility of complex tactual displays

is hampered by the behavioral techniques and the variety of tasks the reader may perform. Consequently, research needs to focus not only on the behavioral techniques and tasks, but also on the design and legibility of the displays as related problems.

In addition, we must look at the early childhood experiences and concepts about space, spatial relationships, and the geography of the child's immediate environment to insure that there is a thorough understanding before introducing a child to a two-dimensional display representing a three-dimensional world.

Furthermore, the concepts and behavioral tasks necessary for reading and interpreting tactual displays appropriate for each age-grade need to be explicitly defined.

Finally, suggestions, comments and ideas from teachers, educators, geographers, and psychologists are needed on the general and specific behavioral techniques, concepts, and concrete experiences the blind child needs to develop in relation to the problems of scanning, reading, and interpreting tactual displays.

Please respond by writing to the author at the address indicated in the footnote.

References

- Nolan, C. Y., & Morris, J. E. Improvement of tactual symbols for blind children: Final Report. Louisville, Kentucky: American Printing House for the Blind, 1971. (HEW, Grant No. OEG-32-27-0000-1012)
- Wiedel, J., & Groves, P. Tactual mapping: design, reproduction and interpretation: Final report. College Park, Maryland: University of Maryland, 1969. (HEW, Grant No. RD-2557-5)

